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Naturalistic Usability Testing of Inpatient Medication Reconciliation Software

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Abstract. Medication history errors are common at admission, but can be mitigated through the implementation of medication reconciliation (MR). We designed multi-media software to assist clinicians with collection of an admission history. This manuscript describes a naturalistic usability study conducted on the hospital wards. Our goals were to 1) estimate the impact of our workflow upon departmental productivity and 2) determine the ability of our software to detect discrepancies. We furnished clinical pharmacists with our application on a tablet PC and asked them to collect a bedside history. We used 1) time-motion analysis to estimate cycle-time and 2) chart reviews to estimate error detection rates. Our intervention detected an average of 7.7 discrepancies per admission (11.7 per pharmacy-shift). A panel rated 67% of these discrepancies as 'high' or 'very high' risk. The cycle-time per admission was slightly longer than usual care processes (20.5 min vs. 17.9 min), but included a bedside interview. In general, pharmacists agreed that the technology improved the completeness and accuracy of a medication history. However, workflow leveling strategies are important to implementing a durable process. In conclusion, a pharmacist-mediated, patient-centered technology holds promise for improving the quality of MR and overall clinical performance.

Keywords. medication reconciliation, electronic health records, human factors, patient safety, usability engineering, usability inspection, sociotechnical

1. Introduction

Medication reconciliation (MR) – a process for gathering and comparing a medication history to organizational documentation – has been heralded as a critical strategy to improve prescribing accuracy and prevent adverse drug events (ADE) [1]. Unfortunately, most institutions have struggled to establish effective MR programs, citing issues of data fragmentation, workload capacity, and poor patient health literacy [1]. The Veterans' Affairs Portland Healthcare System (VAPORHCS) encountered similar challenges. Our hospital relied upon resident physicians to complete most steps, including chart review, history collection, medication prescribing, and documentation [2]. Unfortunately, error statistics and case reports gathered by our local quality division indicated admissions were error prone and documentation rarely met accreditation standards. In response, facility leadership asked our informatics team to devise technology that 1) assembled a complete pre-admission medication list, 2)

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standardized a medication history, and 3) improved electronic health record (EHR) documentation.

Our team developed a software application and engineered a bedside workflow to collect a medication history and identify discrepancies between patient self-report and institutional documentation. Although the software could be used by any member of the care team, we designed our prototypes according to pharmacists' requirements. We sought to apply the cognitive-socio-technical framework described by Borycki and Kushniruk throughout the design lifecycle – incorporating simulation tests with representative end-users at each stage of development from the initial paper prototypes to high-fidelity simulations with software prototypes [2,3]. This paper represents the next step in their evaluation lifecycle: naturalistic testing in a hospital environment to forecast socio-technical issues impacting eventual adoption. We furnished clinical pharmacists with tablet PCs equipped with the software. Our specific aims were to: 1) measure the human resource impact upon our local pharmacy department, including the time required to complete a patient-centered history; 2) estimate our discrepancy detection rate; and 3) identify socio-technical barriers that might impede consistent and skillful use of our technology.

2. Methods

We conducted our evaluation in three discrete phases. First, we completed a baseline assessment of pharmacist workflow focusing upon MR tasks at hospital admission. Second, we introduced the new technology and workflow, providing at-the-elbow support to ensure users were comfortable with the prototype. During this step, the informatics team recorded usability concerns that had not surfaced earlier in development. Third, we evaluated the effect of our technology on the admission process according to two dimensions: time-efficiency (an estimate of capacity) and discrepancy detection rates (an estimate of quality).

2.1. Setting

We conducted our study looking at all inpatients at a 303-bed rated tertiary-care, VA hospital. Medical and surgical teams maintained an average census of 12 mostly geriatric patients (**figure 1, step 1**). The inpatient pharmacy division consists of 12 pharmacists, each covering between 2-4 clinical teams. Inpatient pharmacists were responsible for reviewing patient histories, processing medication orders, assisting with discharges, and fielding consultative questions from physicians and nurses. All providers used the VA's legacy health information system, known as VistA, and its graphical user interface (GUI), the Computerized Patient Record System (CPRS). All inpatient and outpatient prescriptions and dispensary tracking were stored in VistA.

2.2. Description of Technology

Pharmacists logged into CPRS using a portable tablet computer (C5 Motion Tablet PCs, Motion Computing) and accessed our software using an embedded link. Our MR software consisted of three components: 1) a GUI to collect a medication history, 2) a pharmaceutical image database, and 3) an interface with VistA (**Figure 1**) [2]. The software automatically compiled a list of current and recently expired prescriptions

from multiple VA databases. Pharmacists could either scan a list of prescriptions or individually review each prescription matched with an image. The latter format was designed to support a patient-centered medication adherence interview. The interface included on-screen buttons to record patient responses and generate a CPRS note.

2.3. Efficiency Measurement: Time-Motion Study

We used a combination of directly-observed time-motion audits and non-participant ethnography to measure pre-post admission MR time and identify workflow compatibility issues. Using purposeful sampling, we shadowed three pharmacists in four and eight hour time blocks (i.e., half and full shifts) over a span of approximately ten weeks. We modeled our data collection method after similar time-motion studies of hospitalists and pharmacists, adapting previously published categories of pharmacist tasks [4]. During the observation, we gathered qualitative field notes focusing upon usability concerns expressed by the pharmacists. We pilot-tested our instrument for validity and double-coded data samples for reliability.

2.4. Quality Measurement: Chart Review

For each admission during the study, a research team member collected the pharmacist-generated MR note. When available, we also abstracted the physician medication history from the admission history and physical note. We recorded the number, category, and estimated risk of discrepancies identified by pharmacists and physicians. A team of clinicians rated the level of ADE risk using an instrument adapted from Pippins and colleagues [5]. Iterative rounds of double-coding were completed for intra and inter-rater reliability.

3. Results

Patient demographics were typical of poly-medicated US military veterans (**figure 1, step 1)**. We collected 249 hours of time-motion data and recorded 7,055 discrete activities. Pharmacists managed an average of 20.1 patients per day (3.8 admissions per day). However, workload varied according to day of the week, cross-coverage needs, and specialties covered. At baseline, pharmacists used a routine admission workflow. They printed a paper summary of inpatient and outpatient medications and used the printed summary as a reference during chart review. The pharmacists then followed-up with the physicians within 24 hours of patient admit to address any identified discrepancies. Pharmacists did not interview patients. Pharmacists spent an average of 15.2 minutes per admission; approximately 9 minutes were spent on chart review and another 3.4 minutes on paperwork. The remaining time was spent on inter-professional communication. During piloting, pharmacists spent an average of 20.5 minutes on each admission, including an average of 10.6 minutes at bedside. The remaining time was typically used to verify information with secondary sources (e.g., EHR, family members, nursing homes) or communicate findings to the physicians.

In general, observations and quotes tended to cluster around three themes: 1) interface usability, 2) the relative advantage of pictures, and 3) the impact of a bedside interview upon workflow. Pharmacists believed the intervention improved history completeness by automatically compiling prescriptions lists, including recently expired

medications, from multiple sources. They also believed the medication images improved patient recall and drug identification.

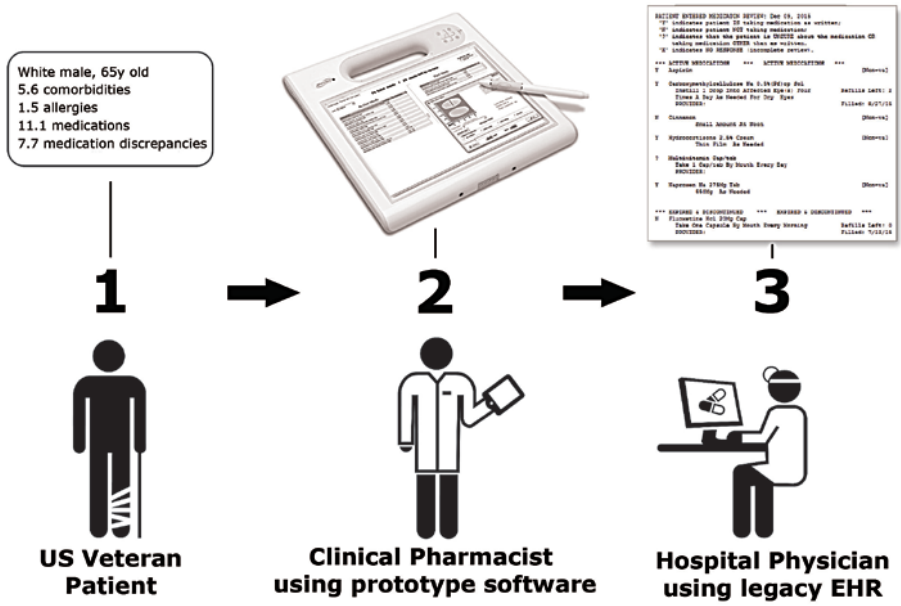

Figure 1. Inpatient medication reconciliation software and workflow with sample screenshots.

Conversely, pharmacists requested more interface flexibility including the ability to sort lists according to pharmaceutical class, fill location, and dispense date. They also asked for integration of patient biometric data (e.g., creatinine clearance). Although pharmacists believed the intervention improved MR quality, they speculated that additional resources, such as pharmacy students, technicians, or "float" pharmacists, would be needed to "level" the workload created by a bedside history, particularly during anticipated peaks in patient volume or gaps in pharmacy coverage.

We collected discrepancy statistics on a total of 69 admission interviews conducted during daytime hours over three business weeks (**Table 1**). We identified a total of 528 discrepancies using our approach (an average of 7.7 per patient and 11.7 per pharmacist-shift). Our clinician panel rated 354 of the discrepancies as 'high' or 'very-high' risk (67% of all discrepancies). Most discrepancies represented either an overlooked or expired medication (36%) or one the patient was no longer taking (31%). The remaining represented differences in dose, route, or patient instructions.

Table 1. Numbers and types of discrepancies identified using our technology and workflow.

Measure	Usual Care	Intervention	P Value
Avg # of medications reviewed with patient	14.9	19.4	< 0.01
Avg # of medications patient reported taking	Not calculable	11.1	NA
Avg # of discrepancies detected per patient	1.1	7.7	< 0.01
Avg # of high/very high risk discrepancies per patient	0.5	5.1	< 0.01

N = 69 patients; 1336 total medications reviewed; p value calculated using Wilcoxon Signed Rank test

4. Discussion and Future Work

By conducting brief, naturalistic usability tests of our MR technology with target end-users in context, we were able to gather information about the merits of our design and potential impact upon patient safety. We also identified socio-technical variables affecting implementation that would not have been evident during earlier simulations. We believe that our approach improved the completeness of a medication history; it identified more medications and detected more discrepancies than usual care. In comparison to similar MR efforts, our intervention appeared to detect a greater number of significant discrepancies per patient (5.1 vs. 0.1-1.4) [6]. Several hypotheses may account for this finding. First, the VA manages the medication distribution supply chain and has direct access to dispensary data. Second, studies suggest that pharmacists tend to collect more complete histories than physicians [7]. Third, the inclusion of medication images may improve patient recall.

Despite encouraging preliminary findings, participating pharmacists identified usability and workflow issues that require attention. Additional functionality such as the inclusion of customizable displays and patient data could reduce MR task time and complexity. Also, the bedside history added roughly five minutes to each admission. We believe our method is a time-sensitive option; our statistics compare favorably to most published time estimates (9-83 minutes) [8]. Nevertheless, future studies should compare this intervention to usual care with a bedside interview. Implementation teams can best address issues of staff capacity by engaging leadership to help with institutional prioritization, resource allocation, and messaging. For example, in our next phase of piloting, we are collaborating with pharmacy leadership and the local pharmacy school to integrate tasks into training rotations, using pharmacy students to conduct beside histories.

In conclusion, our findings suggest that our MR approach can significantly improve the quality and safety of a reconciliation program. For software developers, our findings may inform the design of future patient-centered technologies. For healthcare managers, our time-motion data can be used to forecast clinical capacity and formulate a value proposition when standing up new MR processes.

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